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PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53 (c).

Docket Number	30-561	Type a plus sign (+) inside this box→

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TITLE OF THE INVENTION (280 characters)

SYSTEM FOR PRODUCING ENERGY AT A PULP MILL

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ENCLOSED APPLICATION PARTS *(check all that apply)*

- [x] Specification — Number of Pages: 8
- [x] Drawing(s) — Number of Sheets: 1
- [ ] Applicant claims "small entity" status.
  - [ ] "Small entity" statement attached.
- [ ] Other (specify)

METHOD OF PAYMENT *(check one)*

- [x] A check or money order is enclosed to cover the Provisional filing fees ($160.00)/($80.00)
- [ ] The commissioner is hereby authorized to charge filing fees and credit Deposit Account Number 14-1140

PROVISIONAL FILING FEE AMOUNT ($): 160.00

The invention was made by an agency of the United States Government or under a contact with an agency of the United States Government.

- [x] No.
- [ ] Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,
SIGNATURE J H Nelson

DATE June 7, 2002

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REGISTRATION NO. *(if appropriate)* 30,481

- [ ] Additional inventors are being named on separately numbered sheets attached hereto.

PROVISIONAL APPLICATION FILING ONLY

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U.S. PATENT APPLICATION

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Invention: SYSTEM FOR PRODUCING ENERGY AT A PULP MILL

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SPECIFICATION

SYSTEM FOR PRODUCING ENERGY AT A PULP MILL

BACKGROUND OF INVENTION

[0001] In chemical pulp mills the cooking chemicals of a pulping process are recovered from black liquor by firing the black liquor in a recovery boiler alone or together with other "waste" streams. The firing process is exothermic and the released energy is recovered as pressurized superheated steam. The steam energy is recovered in a steam turbine in form of electric power and low-pressure steam for process needs.

[0002] Energy is produced in a pulp mill mainly by combusting black liquor in a recovery boiler and wood wastes and bark in an auxiliary boiler. The bark of the wood raw material used in the pulping process and the organic substance of generated black liquor together normally cover the whole energy demand of the pulp mill. If more energy is needed, additional electricity or fuel may be purchased. The additional fuel is combusted with the bark in the auxiliary boiler. Today, energy is produced in the following way: a recovery boiler and an auxiliary boiler, where waste bark from the mill is combusted, generate superheated high-pressure steam. The steam hereby generated is forced through a backpressure steam turbine/turbines and the released steam is used to cover the heat demand of the mill. The turbine and the generator connected thereto produce the electricity needed in the mill.

[0003] The wood contains small amounts of potassium (K) and chlorine (Cl) and these elements remain in the black liquor during cooking. In the recovery boiler they are enriched into the fly ash and increase its corrosiveness especially in the superheater area. This limits the temperature of superheated steam typically to 400-490°C, depending on the content of chlorine and potassium. With special materials or with liquors having a very low Cl and K content temperatures up to 520°C have been used. As the temperature of the superheated steam is low, the steam pressure is also low. These limitations result in low power yield from the heat generated in the recovery boiler compared to normal power boilers fuelled by coal, natural gas or oil. These limitations are not as strictly valid with bark originating from logs, but the fly ash from bark combustion in a bark

boiler may also contain chlorine and potassium. As the sulfur content of bark is very low, potassium reacts in the bark boiler with chlorine and forms KCl, which in turn may result in superheater corrosion. Calorimetric flow in bark is also much lower than in the black ("waste") liquor flow, due to much lower mass flow.

[0004] New power cycles developed to replace the conventional recovery boiler - steam turbine -cycle have been studied, pressurized gasification of black liquor and bark being the most promising possibilities. However, a lot of work is needed before these technologies have the necessary reliability and performance. However, no efficient system has so far been developed for increasing the temperature and pressure of superheated steam produced at a recovery boiler plant of a pulp mill in such a way that no corrosion would take place or the corrosion speed would be at an acceptable level. Thus, according to the present invention, a system is provided for increasing the power yield in energy production at a pulp mill so that corrosion problems are minimized.

SUMMARY OF INVENTION

[0005] According to the system of the invention a combustion chamber or cavity is provided in connection with a recovery boiler for the final superheating of steam produced in the superheater section of the recovery boiler. In the system of the invention the steam is heated in the conventional heat transfer sections (i.e. economizers, boiler bank, and superheaters) of the recovery boiler into such a degree that high temperature corrosion does not substantially take place, i.e., below 520°C, optimally 480-500°C, and after that the steam is final superheated to 500-600°C, optimally to 520-560°C in the combustion chamber or cavity, which serves as a final superheater. The recovery boiler can be provided with one or more final superheaters (combustion chambers). In the final superheater/s such a fuel is burned which does not cause high temperature corrosion.

[0006] The walls of the superheater cavity are designed as heat surfaces, preferably as water cooled heat transfer surfaces, which are connected to the main water system of the recovery boiler through connection pipes for the incoming water/steam-water mixture and outgoing water/steam-water mixture. Thus, the heat surfaces form a part of the main

water system of the recovery boiler. The main water system and consequently the water system of the superheater cavity can be of natural circulation type or forced circulation or so called once-through, the latter being typical for the highest steam/water pressures. In natural circulation boilers this means that cooling water is fed via downcomers from a drum down to headers feeding the walls of the cavity or cavities, and water-steam mixture from these walls is collected and fed into the drum. The cavity can have separate walls of its own, but part of the walls of the cavity or part of the walls of the cavities can be common with the "conventional" part of the boiler.

[0007] The interior of the cavity is provided with heat exchanger means for heat transfer from the gas produced in the cavity to the steam flowing in the heat exchanger means. The heat exchanger means serve as a final superheater for the steam from the superheater section of the recovery boiler.

[0008] The optimum location for the cavity is the front wall which is to the "bullnose" wall, but the cavity can be built on side walls too, either as one cavity, or as several ones. The location or locations of the cavity or the cavities can be in the vertical direction anywhere, in the relation to the conventional part of the boiler, limited only by the cooling water circulation.

[0009] The superheater cavity for the final superheating of the recovery boiler steam is heated by burning fuel. A burner or burners for the fuel are located at the top of the cavity, at the bottom of the cavity, or on the walls of the cavity. The cavity can also be located in a horizontal position, when the most preferred location for the burner or the burners is on one end wall of the cavity.

[0010] The combustion air system of the superheater cavity is a part of the combustion air system of the recovery boiler. It may also have a separate air system with an air fan of its own, connection ducts between the fan and the burner(s) and any necessary equipment for the combustion air control.

[0011] The superheater cavity for the final superheating of the recovery boiler steam is heated by burning fuel in such a manner that noncorrosive conditions in the superheater cavity are guaranteed. The fuel can be a gas produced by gasifying biomass. The corrosion of heat surfaces can be avoided by additional combustion of sulphurous fuel. Also the cleaning of the gas before the combustion in the superheater cavity guarantees noncorrosive conditions at higher temperatures. Instead of the gas produced from biomass other fuels can be used, e.g. natural gas, LPG, liquefied biomass, methanol, etc. The criterion for the fuel is the noncorrosive nature under the cavity conditions. The fuel combustion in the cavity is normally complete with optimized amount of excess air, but stoichiometric or reducing conditions are also possible, if preferable.

[0012] The offgases of the superheater cavity are lead into the recovery boiler, preferably to the inlet of the main superheater where they are mixed with the main gas stream coming from the boiler furnace. Other locations for the gas connection are possible as well: the whole area from the lower part of the furnace to the inlet of the economizer. The offgas connection through the boiler wall consists preferably of more than one opening.

BRIEF DESCRITION OF DRAWINGS

[0013] These and other features and advantages of the invention will be described with reference to the following drawing of an embodiment of the invention:

[0014] FIGURE 1 shows schematically a cross-sectional view of a recovery boiler with a superheater cavity.

DETAILED DESCRIPTION OF INVENTION

[0015] By means of the invention the pressure and the operating temperature of the steam recovered from the waste liquor recovery process is increased by means of the superheating boiler, whereby the overall electrical efficiency of the plant is improved, i.e., more power is generated by the heat recovered in the steam.

[0016] The invention will now be described in more detail with reference to the accompanying drawing in which one embodiment of the invention is illustrated schematically in Fig. 1. The reference numbers are as follows:

[0017] 1. Conventional recovery boiler

[0018] 2. Cavity

[0019] 3. Furnace of the recovery boiler

[0020] 4. Floor of the conventional boiler

[0021] 5. Char bed in the conventional boiler

[0022] 6. Primary air ports

[0023] 7. Secondary air ports

[0024] 8. Liquor spraying equipment

[0025] 9. Tertiary air ports

[0026] 10. Water cooled furnace walls

[0027] 11. Bullnose

[0028] 12. Superheaters in the conventional boiler

[0029] 13. Boiler bank

[0030] 14. Economizers

[0031] 15. Flue gases leaving the boiler

[0032] 16. Feedwater entering the boiler

[0033] 17. Feedwater entering the drum in the described natural circulation boiler

[0034] 18. Drum

[0035] 19. Saturated steam entering the superheaters of the conventional part of the boiler

[0036] 20. Superheated steam from the conventional part of the boiler entering the superheater(s) in the cavity

[0037] 21. Live steam leaving the boiler

[0038] 22. Burner or burners in the cavity

[0039] 23. Flame or flames in the cavity

[0040] 24. Superheater or superheaters in the cavity

[0041] 25. Headers of the cavity to feed cooling water from the drum (18) to the walls of the cavity

[0042] 26. Flue gas flow from the cavity

[0043] 27. Flue gas flow from the furnace of the conventional boiler

[0044] 28. Fuel feed to the gasifier

[0045] 29. Gasifier

[0046] 30. Gas to the burner or burners of the cavity

[0047] 31. Gas cleaning or other type treatment for gases leaving the gasifier for other purposes than for the cavity (2)

[0048] 32. Gas cleaning or other type treatment for gases leaving the gasifier for the cavity I-III superheaters in the conventional part of the boiler, and IV superheater in the cavity

[0049] The furnace 3 of a typical recovery boiler, such as a soda recovery boiler, used for the combustion of black liquor, has a structure formed of a water-cooled bottom 4 and water-cooled walls 10 made of a compact membrane structure, so that a water-steam mixture under pressure flows in the tubes. The water-steam generated in this way is superheated downstream of the furnace, typically in a conventional superheater 12 located in the shield of a "nose" above the furnace. In the superheater the heat of the flue gases 27 generated during combustion is recovered. Typically, a boiler bank and an economizer serve as the after-heat surface in the boiler, and after the superheater the flue gases are directed into the boiler bank 13 and economizers 14. The generated high-pressure steam is typically further used by directing it to a steam turbine, so that electricity and process steam needed at the mill are generated.

[0050] The lower section of the furnace and the bottom 4 of the soda recovery boiler are made of water-cooled tubes, which constitute a part of the pressurized section of the boiler. Due to the structure of the bottom and the lower section of the furnace, there is natural circulation of water in the bottom tubes, i.e., the circulation is effected by a difference in density. The boiler water is thus led at a high pressure and at a temperature of, for example, about 300°C to a distributing header (not shown) below the bottom of

the furnace, from which the water is distributed into the bottom and side wall tubes. In the lower section of the furnace, the water flows first nearly horizontally or obliquely upwards in the bottom tubes towards the walls, and then further upwards through the wall tubes to the upper section of the boiler.

[0051] The invention is based on a recovery boiler, where steam pressure is such that excessive corrosion does not take place, i.e., the saturation temperature in water-steam emulsion plus the temperature difference due to incoming heat flux from the tube surface into water is less than 400-500°C, which is the tube surface temperature.

[0052] The steam temperature can be increased over the typical figures by integrating into the conventional recovery boiler 1 a special combustion and heat transfer chamber or cavity 2. The steam is superheated in the conventional superheater part 12 to such a degree that high temperature corrosion does not take place, e.g. 480-520°C, optimally 480-500°C and the rest of the superheating up to 500-600°C, optimally to 520-560°C, takes place in a superheater or in superheaters 24 in a special combustion and heat transfer cavity 2 integrated into the recovery boiler, where the fuel to be burned in a burner or burners 22 with flame or flames 23 is so clean that it does not cause high temperature corrosion. Flue gases 26 from the cavity 26 are introduced into the flue gas stream 27 of the conventional part of the recovery boiler. Preferably the flue gases of the cavity are directed through several openings in the wall of the recovery boiler.

[0053] The cavity 2 is a part of the conventional recovery boiler, so that the walls of the cavity are water cooled as in the conventional part the furnace, in the boiler bank and in other hot areas, and this cooling is integrated into the drum 18 or into the drums of the conventional boiler with natural circulation. In once-through type boilers this integration means that the walls of the cavity are cooled by the water or steam flows of the once-through system. Same type of integration with circulation water is also valid for forced circulation type recovery boilers, if this arrangement is used. The main advantage is the introduction of heat from the cooling of the cavity into the same pressure water or steam flow or flows as in the main flow of the "conventional" part of the recovery boiler. The

cavity has a combustion chamber or several combustion chambers, and heat transfer surfaces for the superheater or superheaters. Air for the combustion can be taken from the "conventional" part of the recovery boiler or the cavity may be equipped with own fans or compressors.

[0054] According to a preferred embodiment a combustion gas 30 for the cavity is produced in a gasifier 29 by gasifying biomass material 28. Then a part of the gases is used in the cavity as clean fuel 30 in the burner 22 to superheat the steam in the superheater 24 (IV) and also for re-heating purposes. Part of the gases 33 is used for other purposes at the pulp mill. If this type of fuel is not available, other fuels like natural gas, LPG, oil, methanol, liquefied biomass etc can be used. The criterion for the fuel is the noncorrosive nature under the cavity conditions. This noncorrosive nature can be created in the gas from gasification 29 by cleaning the gas in treatment 31 or 32.